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Title: Global Teleconnections: Atmospheric Interactions Across Scales

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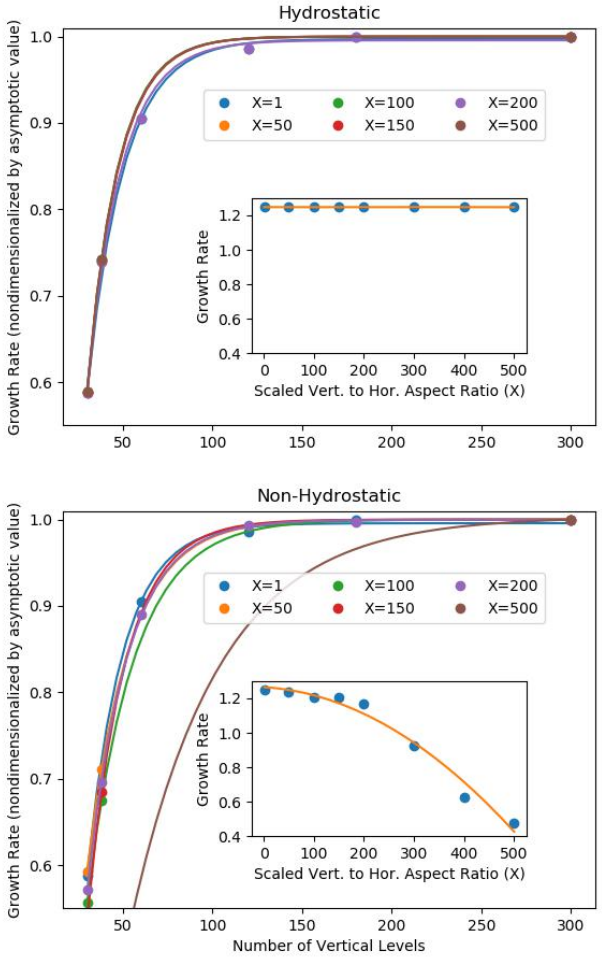
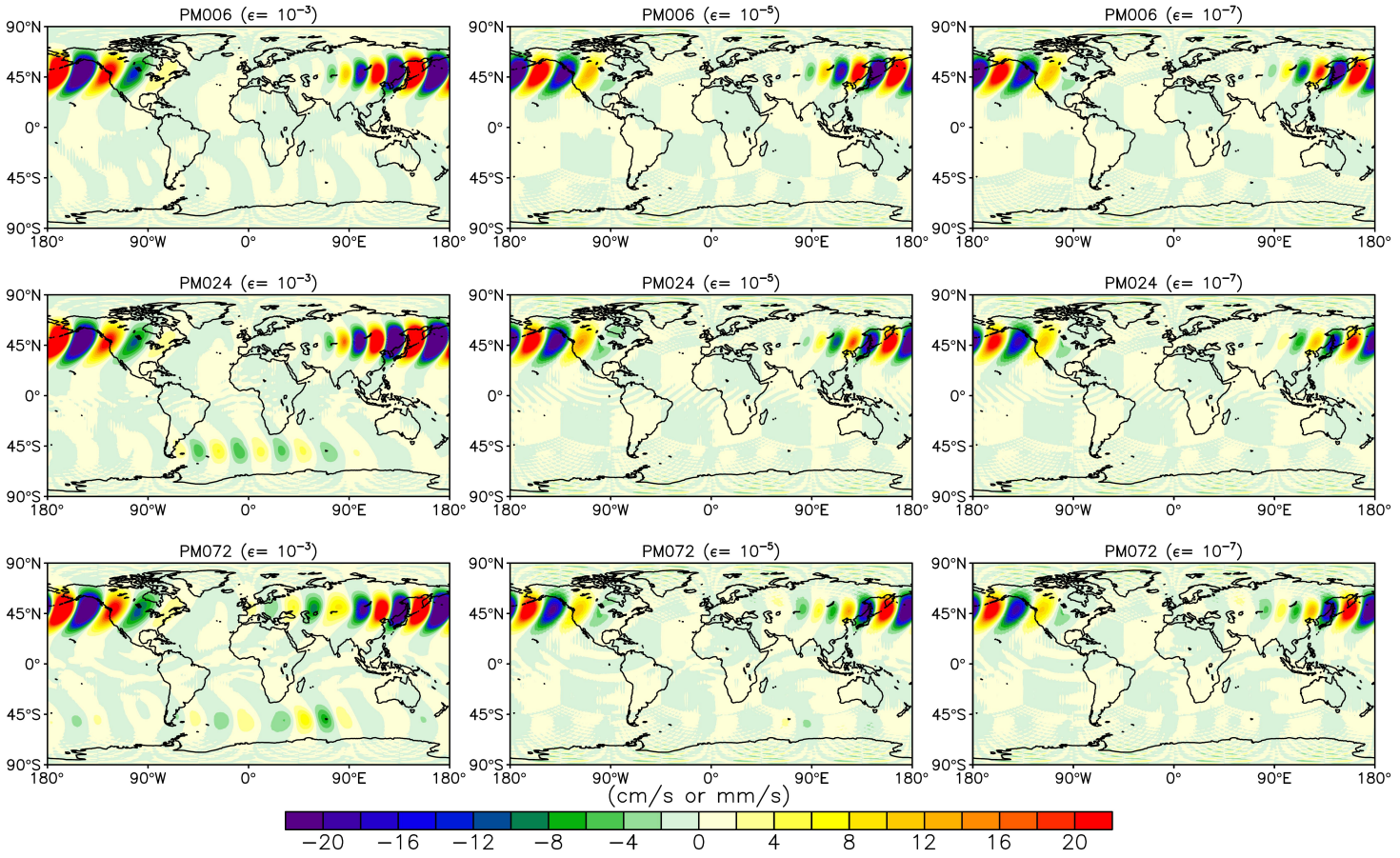
# Global Teleconnections: Atmospheric Interactions Across Scales

## Overview

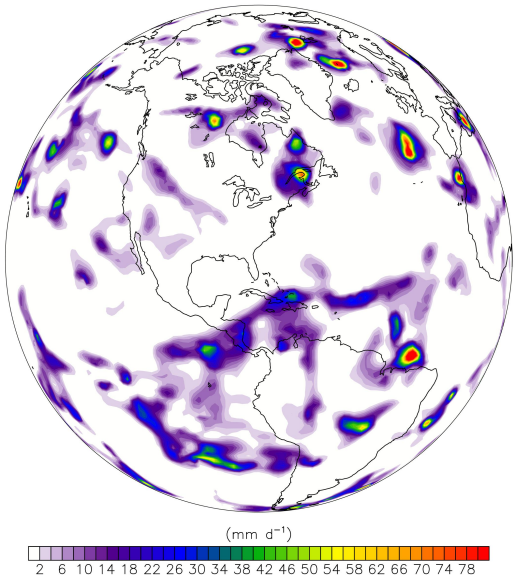
This project aims at an improved understanding of non-hydrostatic dynamics in atmospheric modeling using the DOE's next generation climate model. One aspect that we have been focusing on is **baroclinic instability** which is closely related to mid-latitude cyclone genesis. The other aspect that we recently developed is **E3SM simulations under Radiative-Convective Equilibrium** (**RCE**), a prototype of tropical climate.




**Baroclinic Wave Growth Rate:** Decreases as non-hydrostatic effect increases, and varies strongly with vertical resolution.




**Baroclinic Wave 500-hPa Meridional Wind Perturbations after Incorporating Power Method (PM) into HOMME-NH:** PM is applied at every 6, 24, and 72 time steps in the top, middle and bottom rows, with parameter ϵ as $10^{-3}$, $10^{-5}$, $10^{-7}$ in the left, center and right columns. The patterns are robust to the details of how the PM is implemented.




**E3SM-RCE Precipitation**: Snapshot at day 300.

## E3SM-RCE Compset Development

LANL: Sun and Nadiga

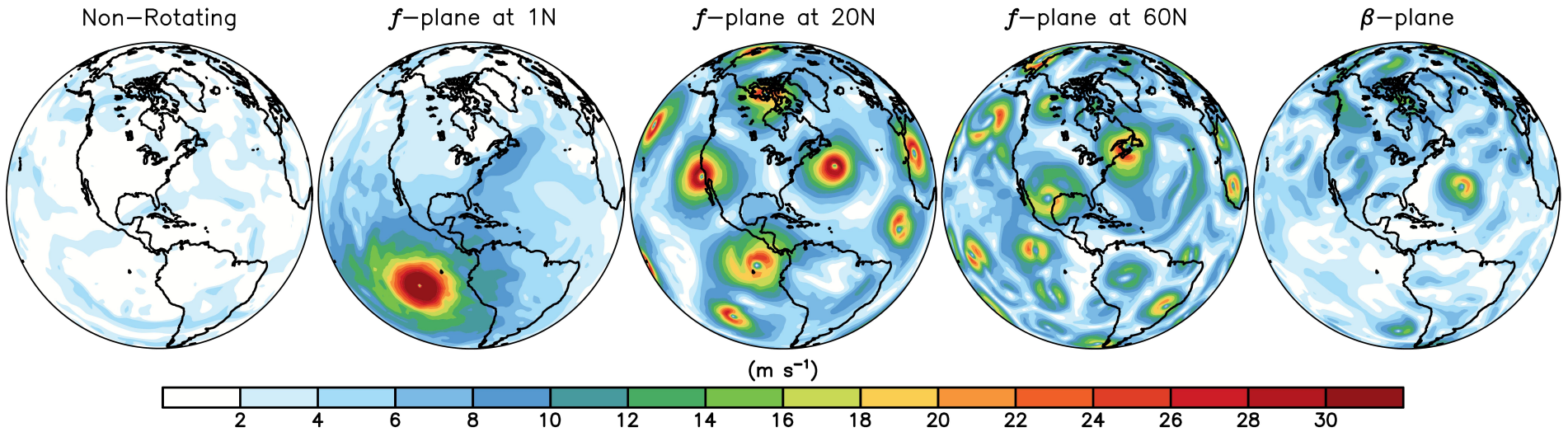
- Removed Coriolis effect (Sep. 2019)
- Introduced thermal seed and surface layer gustiness (Oct. 2019)
- Fixed multiple model constants per RCEMIP (Oct. 2019)
- Added diurnal cycle option for RCE (Nov. 2019)
- Added *f*-plane approximation option (Dec. 2019)

LLNL: Hannah and RRTMGP developers

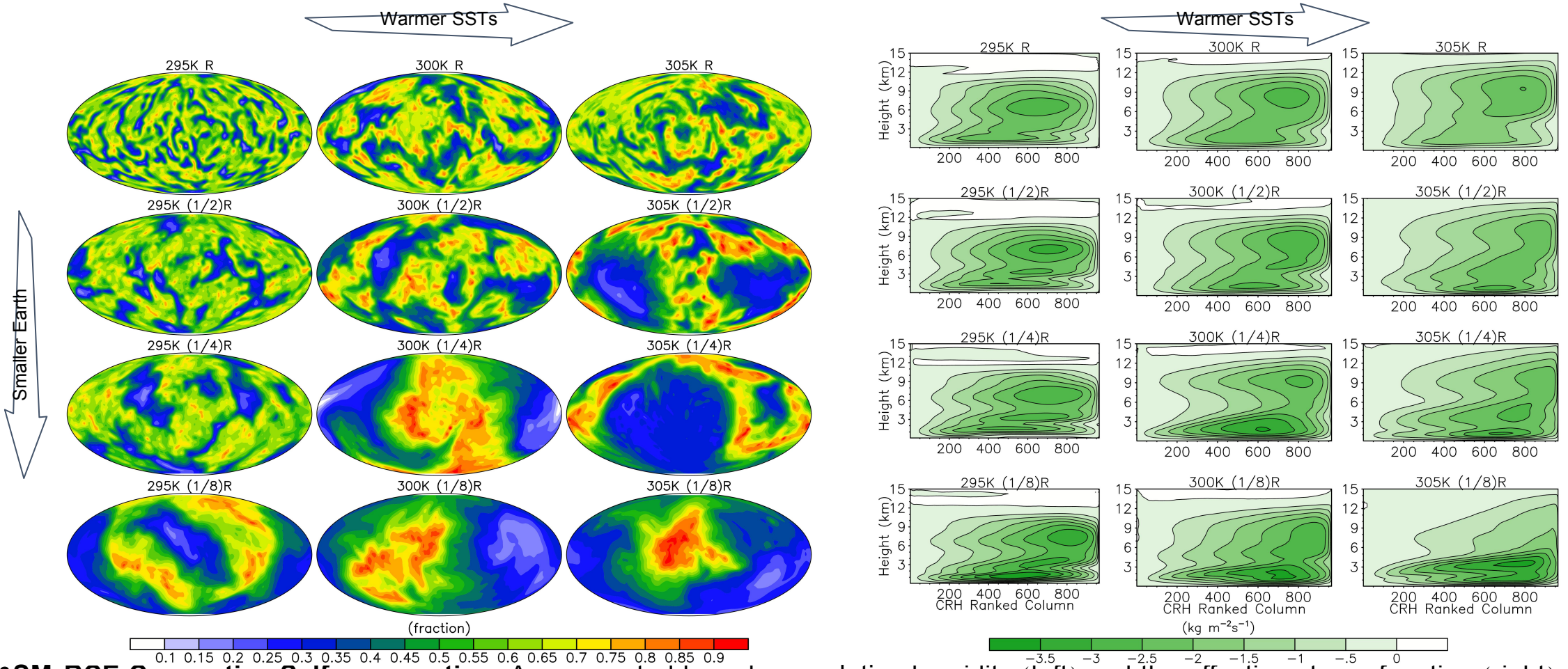
- Fixed SST (Sep. 2019)
- Introduced globally uniform radiation (Sep. 2019)
- Removed direct aerosol radiative effect (Sep. 2019)
- Fixed issues related to gravity wave schemes (Jan. 2020)

Initial condition is derived from a single column E3SM run following the RCEMIP protocol

Most options are available via namelist




**E3SM-RCE Surface Wind**: Rotating RCE simulations with *f*-plane approximation reproduce the scaling theory of TC-like vortices ($R \sim 1/f$). Under β-plane approximation, TC-like vortices are displaced toward the polar regions as expected (*R* denotes the size of TC-like vortices and *f* is the Coriolis parameter).




**E3SM-RCE Convective Self-aggregation**: As suggested by column relative humidity (left) and the effective streamfunction (right), moist convection tends to aggregate over warmer sea surface temperatures (SSTs) on smaller planets with finer effective resolutions in E3SM.

## Scientific Impact

Using PM, we quantified non-hydrostatic effect on baroclinic waves. These results are informative on numerical simulations of mid-latitude weather and climate.

The development of RCE Compset enables idealized RCE simulations in E3SM for the first time. Its rotational variation allows future studies of tropical cyclones. Comparisons with other RCEMIP participating models will also provide us the opportunity to identify E3SM limitations and biases.

## Financial Impact

Studies under this IC project contributed to a recent renewal of the LANL-SNL SciDAC project (NH-MMCDG) in 2019, which brings in about 2.5M over 2.5 years (about ~1M over 2.5 years to LANL).